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Hot Iron

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Contents

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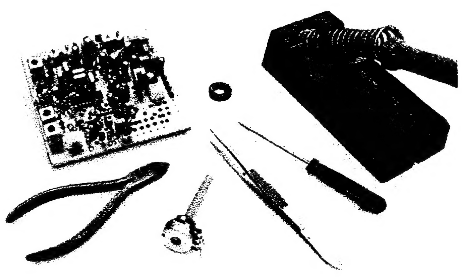
Editorial



Last night Tony Blair signalled a push on nuclear power stations supported by extra work on renewable generation and other items designed to save energy. All very sensible! It makes me feel slightly smug that my solar panel is now charging - even on this dark rainy day! Since writing last about it, when I contemplated driving much of the house lighting circuits from a static inverter, I realised that the modern 12 volt AC 'low voltage' lighting and associated fittings is entirely suitable for DC use also. I have now installed a DC supply from my main storage batteries around the central parts of the house, complete with small tungsten halogen light fittings. This works well and will reduce the 50 Hz consumption appreciably from those lights which were often left on for long periods. I have used large section cables from the batteries to the middle of the house, so that I can easily connect a static inverter there to power the TV and heating etc, in the event that the 50 Hz does fail. Maplin Electronics have been selling a 12 volt 600W (1500W surge) inverter for near £50 which makes doing your own uneconomic. The whole 'investment' has a very long payback period but is all good fun!! Tim

Kit Developments

Quite a few things going on! The revised signal generator turned out to be too complex and finicky so I have started afresh with a simpler design, without the VFO frills. If all goes according to plan it will have nominal output of about 10 dBm (analogue or digital) over at least 1 to 30 MHz. In a similar vein, and with a fair bit of prompting from a good supporter in Norfolk(!), I have designed a new All Band VFO kit. This does all the traditional bands by crystal mixing with digital dividers but also avoids having an excessive tuning rate or span on any band! See later for the concept. It might even drive an All Band CW TCVR but that is another story!

I am also working on a 1.5W DSB phone TCVR called the Brean. This will be essentially 'crystal' controlled and suitable for any band up to 20m. Either a pullable ceramic resonator for 80m, or for the higher bands, an actual crystal or a wider tuning range with the Mini Mixer kit.

The other major project is the Minster. This is progressing steadily but it is not something to be rushed given the complexity of multi-band operation etc.

None of this helped by my **being away on farming business for most of July!** Sorry about that but I will deal with any queries immediately on my return. Regards, Tim G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics– is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ

Diode Abuse!! by Richard Booth G0TTL

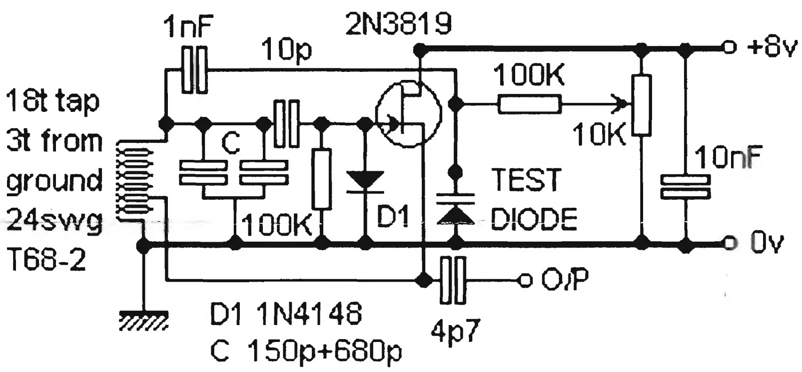
Purpose built high capacity varactors or as I know them varicap diodes are now a thing of the past. Philips stopped making the useful BB212 several years ago with supplies quickly running out, and like everything else in short supply prices for the remaining few are increasing at a rapid rate. The reason for this in much the same way as 10K TOKO coils are now becoming extinct is that very few if any new commercial designs have traditional L/C tuned circuits. Cheap direct digital synthesis IC's and PLL circuits nailed the coffin closed on this chapter of analogue electronics.

However if your thoughts, like mine are about building and maybe designing useful and relatively easy to construct amateur radio projects then you needn't worry too much about that problem. Not all components do just what they say on the packet - take for instance the old trick of scratching the paint from a germanium OC71 and hey presto you have a photo transistor. Or maybe Tim's favourite of using digital logic gates as linear amplifiers or oscillators. It's all about lateral thinking which to my mind makes building your own equipment all the more interesting.

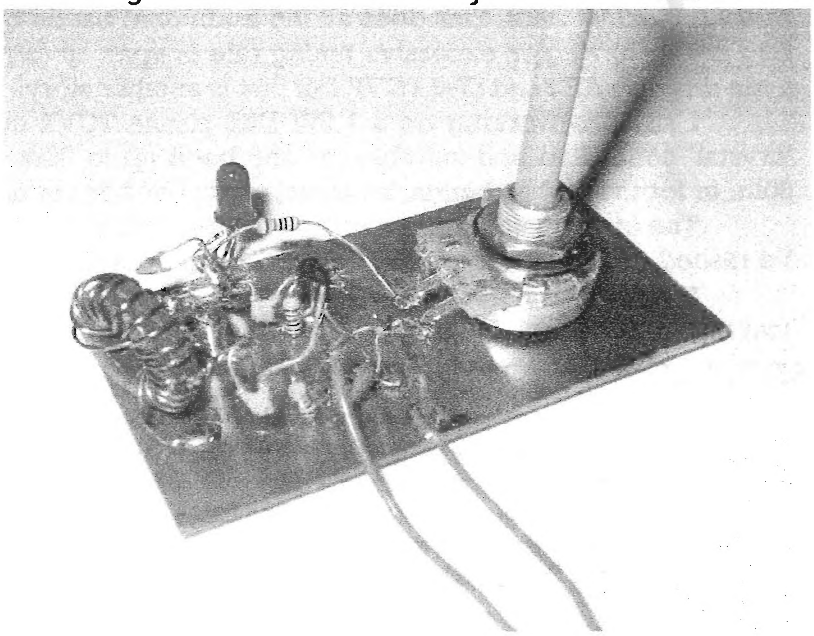
For some time now I've been pondering over a few rig ideas which one day all being well will come to fruition. The VFO has been one of the sticking points, simple mechanical arrangements and only using a variable capacitor as a last resort were my thoughts. So a varicap alternative would need to be found. It's well known that all diodes exhibit some level of variable capacitance when a reversed bias voltage is applied across it. So the plan was to test a selection of readily available diodes and get some meaningful results.

First of all I threw together a simplified version of the Midney VFO circuit, originally designed for the BB212 diode and changed a few things around, to make it run at 4 MHz, substituting the 10K TOKO coil for a tapped toroid and did away with the voltage stabilising components. Running direct from the bench power supply at 8V was good enough for this test.

Simple 4MHz test vfo



The circuit was constructed dead bug style on a small piece of PCB material. 1MΩ resistors were used as standoffs. No frills and definitely not to be repeated in an actual transmitter! As a first test just to make sure that the circuit was working I soldered in a BB212. Just less than 500 KHz of swing was available with the selected component values, with the oscillator running between 4 and 4.480 MHz. I then proceeded to test various diodes including LED's which yielded some odd results!



How not to build your next VFO!
This picture shows my quick lash up VFO board. A red LED is being tested.

Diode Abuse Continued

After reading about success using Zener diodes in this application I was surprised to find the actual results obtained to be so poor - see the Table right. Strangely the LED's however worked quite well as a varicap, although it does seem to be colour dependant! The green types (and I tried several different makes to check this) all seem to have an odd hysteresis effect in that their tuning range is different depending on the direction of the reverse voltage, i.e. going low to high and vice versa.. I expected the larger sized LED's to have a higher total capacitance due to their internal dimensions but again strangely this is not the case. The big surprise though was the 1N54 series of diodes. Rated at up to 1 Kv the 1N5408 turns out to be the winner of best substitute varactor of 2006. Although it's quite a chunky power diode it's not much bigger in PCB space terms than the BB212, especially if mounted up on one end. Tuning across the range seems to be reasonably linear.

So it would appear that several suitable alternatives are available, all of them costing 15p or less. The zener types are probably best suited for RIT or fine tuning control.

Diode Type	**Oscillator Swing at 4 MHz**
BB212 dual Varicap	480 KHz
BZY88 5V6 Zener	10
BZY88 12V2 Zener	11
BZY88 36V Zener	13
1N4007	70
1N645	70
1N4148	20
Red HE 5 mm led	125
Red HE 3 mm led	135
Green HE 5 mm led	40 with hysteresis!
White 5 mm led	120
Red 10 mm led	45
BA148	40
BY127	25
1N5401	150
1N5404	200
1N5406	245
1N5408	305 KHz

A practical example

Just to prove to myself that this would actually work in practice I removed the BB212 from my 160M Midney superhet receiver and replaced it with a single 1N5408 diode. This is my test bed receiver built on a lump of old timber to make it a bit sturdier with numerous sockets for checking IC's and transistors which I have a habit of killing. Without changing any of the frequency dependent capacitors or inductors I'm pleased to say the results were good. Just a quick tweak of the VFO TOKO coil and an adjustment of the 10K tuning range preset had the receiver tuning 1.8 to 2 MHz with no real difference from its original performance worth noting. For novelty, having never had a receiver tuned with an LED before I also tried fitting a single red 5 mm led. At this frequency 100 KHz of the band was covered - this of course could be increased by altering the capacitors in the oscillator circuit.

Do let me know how you get on if you use any of the diodes I tested, or if you know of any other types worth trying out. 73 Richard Booth, G0TTL

Caution!!

Richard's excellent piece of work reminds me of the point that the ordinary 78 series fixed voltage regulators are just NOT good enough to provide the supply for main tuning by a varactor diode. This applies to any device of the 78 series, irrespective of their size! The variation of output voltage with changes in output load current, and with changes in input voltage, is too great for a decent rig. Its frequency will jump about as the volume alters!! The LM317 range of adjustable voltage regulators are almost an order of magnitude better in both key respects! Thus if you do contemplate using a varactor for a wide tuning range (say more than 25 KHz), then use a 317 regulator (L or T type) for the supply feeding the tuning pot. If you only need a small tuning range, such as for Fine tuning or RIT, then the 78 series or other fixed ones maybe adequate.

I am hoping Richard will report soon on the temperature stability of the 1N5408. Tim G3PCJ

Shack Standards by Gerald Stancey G3MCK

When using a voltmeter I wonder how many of us stop and think 'I wonder if the meter is correctly calibrated?' In a professional laboratory this problem is, or should be, taken care of by having a procedure where the calibration of all test equipment is regularly checked and recorded to give a certifiable audit trail. The professionals use specialist test–houses for this function and it costs money.

So what can the amateur do? Ignore it and hope that no problem ever occurs or spend big bucks. There is a third way which while not being high precision is better than nothing. You simply measure the voltage of a new Duracell PP3 battery and assume that it is 9.5 volts. Hey I hear you say, this is real simpleton optimism but just think, if the battery is really 9.4 volts your error is only 1% and this is not at all bad. Hence this method while not being of test-house accuracy, will at least show if your meter is really up the pole. Another possibility is to use Zener diodes or voltage regulators but I have not investigated these. Precision voltage standards are also available but these do not seem to offer very much better accuracy.

Readily available frequency standards is an area where we seem to have regressed. In the old days it was simply a matter of checking your 100 KHz standard against MSF on 5 MHz or the BBC on 200 Kc/s, note the use of c/s rather than Hz to keep in sympathy with the times. However all is not lost as the People's Republic of China make standard frequency transmissions on 2.5, 5, 10 and 15 MHz to an accuracy of better than 10 in 10^{10} . They identify as BPM in CW at H+29 and H+59. I have used the 5 and 10 MHz transmissions.

Another possibility is to use standard BC stations. In the medium wave they are all channelled at 9 KHz spacing and their frequencies evenly divide by 9 so 900 KHz, 909 KHz etc are all BC channels. The shortwave BC stations are even better as they operate with 5 KHz channel spacing. I do not know how accurately they control their frequencies but the BBC control to 1 in 10^8 . Checking a number of BC stations in the 40m band suggest that their accuracy is adequate for normal amateur use.

This raises the question ' how accurate do you need a standard to be'? The answer depends on what you want to measure but a rule of thumb is that the standard should be ten times better than the accuracy to which you need to measure. The post war amateur licence required an accuracy of 1 in 10^3 , ie 1 KHz per MHz. If we assume that BC stations control their frequency to better than 1 in 10^5 , ie 10 Hz per MHz then it appears that they will make adequate standards for amateur use.

Frequency checking technique

Its not too easy to check an oscillator against a BC station but this is what I do! Tune in the BC station, preferably on a very stable direct conversion receiver. Adjust the tuning for zero beat of its carrier. Wait and see if either drifts away and no longer remains at zero beat - hopefully not! Then introduce the output of your test oscillator also to the receiver, ideally this would be at about the same signal level as the broadcast station. So it is likely to need quite a lot of attenuation. It might be adequate just to bring the oscillator near the RX input. (The oscillator should have been switched on well in advance so that its temperature has stabilised before the comparison.) When the oscillator signal is introduced to the RX there might be a low audible whistle, or the AGC might pump at a few tens of Hz if it has AGC. Twiddling the oscillator's frequency trimmer might swing it far enough to make the frequency difference audible; but in any case you actually desire that the beat frequency between BC station and test oscillator be zero! You often have to listen exceedingly carefully to detect any 'signal' once the difference in frequency goes sub-audible at roughly 20 Hz. If the RX does have AGC, one can sometimes hear a change in the background noise level as the gain alters at the beat frequency. Failing this, you will have to set the trimmer mid way between the two points at which you can just hear the note with the same frequency. Do this and you wont be far out bearing in mind that the error is in tens of Hz for a carrier of several hundred KHz! Tim G3PCJ

Ideas for an All Band VFO!

Prompted by David Proctor's article last time and Andy Howgate, I have often contemplated how to make an 'all band VFO'. At first sight it is easy! It needs good stability so a crystal mixing scheme is almost obligatory - and it would of course prevent chirp when used to drive a transmitter. So all you have to do is mix a low frequency VFO with a crystal to get 28 MHz, and then divide the output down for all the lower bands. There are two big snags; firstly it needs a tuning range of 28 to 32 MHz to divide by 16 for 1.75 to 2.0 MHz, this is a bit wide for easy tuning/stability and there is a 2:1 change in tuning *rate* for all bands compared to the next above or below! The other problem is that it cannot do 21 MHz as this is not a binary multiple of any band.

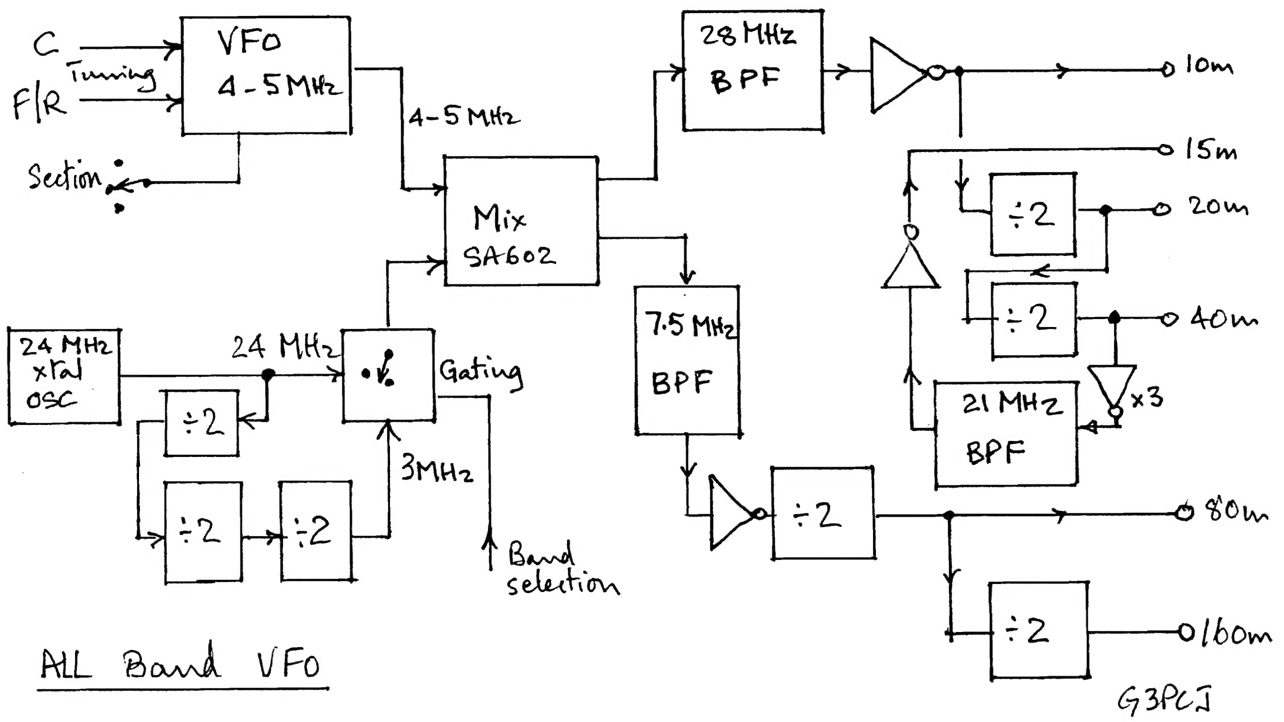
After many doodles and much head scratching, I realised that the two outputs of a SA602 might offer a solution. One could drive a BPF for 28 MHz and then be squared up in a digital gate, followed by two stages of digital division to get down to 7 MHz. The change in tuning rate would be limited to 4:1 overall and a 1 MHz swing at 28 MHz would give coverage of all of 20 and 40m. The other output could drive a second BPF covering 7 to 8 MHz, which with squaring, could again divide down for 3.5 to 4 and 1.75 to 2 MHz. Clearly the inputs to the mixer would have to suit each active BPF. One input could be an actual VFO covering 4 to 5 MHz, the other mixer input being the 602's internal oscillator using crystals of 24 and 3 MHz! A 2 pole 6 way range switch could select the BPF/ divider output and crystal.

How to get to 21 MHz though? This is the third harmonic of 7 MHz and what are square waves rich in? Odd harmonics. We already have 7 MHz square waves divided down from 28 MHz, so feeding this 7 MHz into a 21 MHz BPF should select the desired third harmonic content, which can be squared up afterwards. Easy!

The above scheme would need crystals of 24 and 3 MHz, but 3 MHz is not a standard readily available value. By luck 3 is a binary sub-multiple of 24! So a further divide by 8 stage would get us 3 MHz from a single 24 MHz crystal and then only need gating to select the right output. This would be rather more reliable than actually switching over the crystal directly by the band switch. The resulting block diagram is shown below.

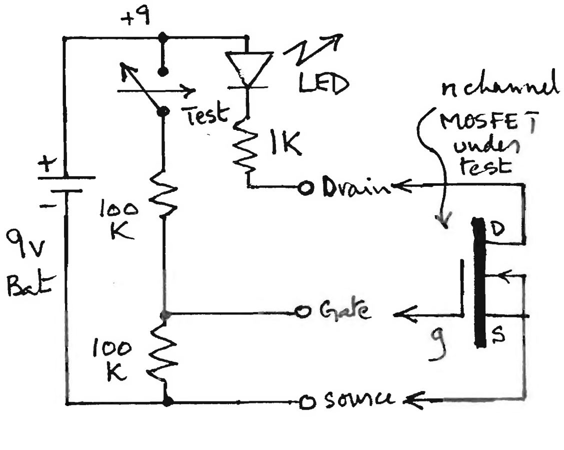
Clearly stability will be important if it is to be used for a rig's VFO, so suitable toroids and capacitors would be best. The 1 MHz tuning range needs dividing into sections with the provision of a further Fine tuning control being desirable. If this Fine control used varactor tuning, then it is easy to make this also double as a RIT control making the VFO directly suitable for a DC CW rig.

I have laid this out as a main PCB with a small upright front panel and will try it out shortly. With some other ideas, it also holds the prospect of an All (traditional) Band CW TCVR! Tim G3PCJ



Testing n channel MOSFETS

Small MOSFETS, like the n channel BS170 are so cheap, that if there is any doubt about them, it is almost the best thing to throw them away and fit a new one! Nevertheless, this little device will test them just as well as the larger n channel types such as the IRF510, which are definitely worth testing. First of all you need to identify the gate lead. The safest thing is to look that up in a data sheet or on a circuit where it should be given. The next thing is to connect the source and drain leads to the circuit with the gate connected also to its test point/button.



n channel MOSFET Tester G3PCJ

Switch on, if the source and drain are the correct way, the LED should not light; but if it is the wrong way round, the LED will light irrespective of the gate voltage/test button - this is because the transistor looks like a diode when the supply is the wrong way round. If the LED does light, change the source and drain around and check that the LED now goes out! If it still stays on, throw it away, because the device is short circuit! This is an uncommon failure mode.

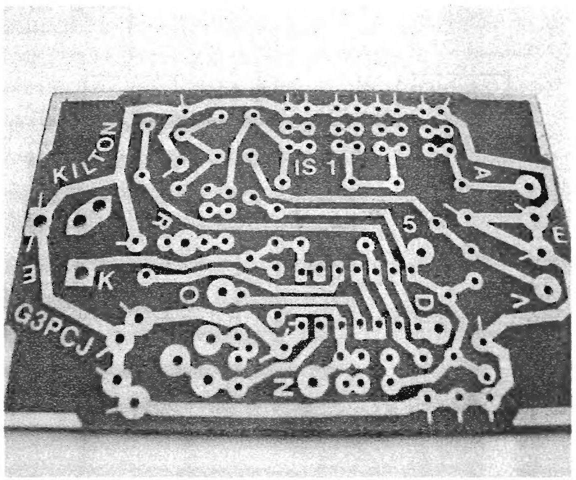
Assuming that it did not light when first connected or went out after changing the source and drain leads, then press the test button; if the LED does now light, all is well with the device. If the LED still does not light, the device is open circuit and no good!

The circuit can also be used to check **diodes**; the LED should light when the diode anode is connected to the drain terminal and cathode to source terminal. The LED should not light when the diode is connected the other way round. If it is on both ways the diode is short circuit and fit only for the bin! (This circuit cannot be used for testing p channel MOSFETs.) Tim G3PCJ

Laying out PCBs

If space allows, the best strategy is for the main signal flow to be in a straight line so that there is the largest separation between low and high level signals. If this is unavoidable, then make certain that adjacent low and high level signals are at different frequencies! Next arrange the layout so that all high current stages have good grounding, short leads and are near output RF filters so that the high currents don't go near the sensitive low level circuits. In the example PCB below (the Kilton CW transmitter), the output transistors are on the top left, feeding the TX low pass filter in the top middle, which in turn feeds the output on the right. A common wide earth track links all these stages and the output. In this example, the driver stages are in the middle in the integrated circuit and the VFO components (trimmer and ceramic resonator) are at the front left - as far as possible from the high current part. The control circuits are at the front right. Although this is actually a double sided board with a copper ground plane on the other side of this photo, all the earthy points are also linked together by tracks to minimise the effects of any forgotten top-side solder points, and to help reduce the impedance between any two grounded points. I find that I can lay these circuits out more quickly using a form of rub down tapes than I could do if I were to use software. (I also don't get the square eyes!)

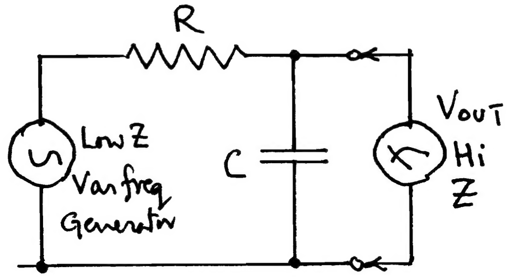
Because I make many samples of the same PCB, I use a photo etching process where the track image is first impressed on the board by an UV sensitive chemical; this is then developed to leave a resist that prevents the ferric chloride from etching away the wanted copper track pattern. The standard drilling process that Brian Purkiss and I have developed, is to first drill the earthy holes - these have hairs on them like a chassis symbol. Then Brian countersinks these holes on the ground plane side to prevent their component leads being accidentally grounded. Finally he drills the non-earthy holes. The copper resist is then rubbed off with wire wool and the board sprayed with a lacquer that prevents oxidation but which can be soldered through. Tim G3PCJ



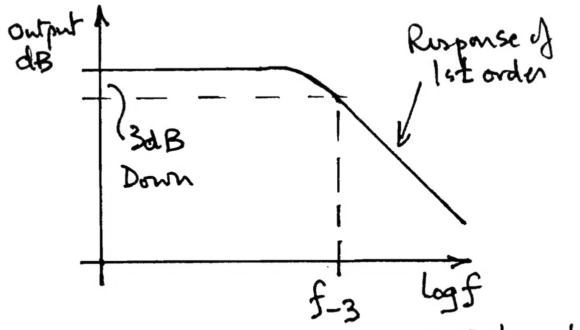
Theory - Low Pass Audio filters

These are an essential building block of all electronic devices! A sweeping statement you might say - but nevertheless it is true! Even the humble coupling network between two stages of an audio amplifier is potentially a low (or maybe high) pass filter.

Let first consider the response of the most simple R and C network shown right fed from an ideal low impedance source and with a very high load impedance, so that both those aspects can be ignored. As the generator frequency is increased, initially there is no change in output level, but at some frequency f_{-3} , the output level will begin to reduce and then go on steadily decreasing for ever! The output actually decreases by 6 dB per octave or 10 dB per decade - they are the same slope of the response line. This said to be a first order low pass network as there is only one CR time constant. The frequency where the bend occurs, and the response is actually 3 dB down (voltage) or to 0.707 of its DC value, is actually where the impedance of the capacitor is numerically the same as the resistor. So you can work out that frequency from:-

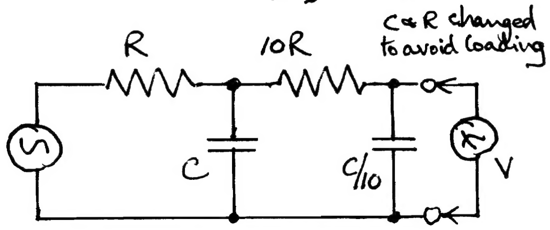


FIRST ORDER LOW PASS



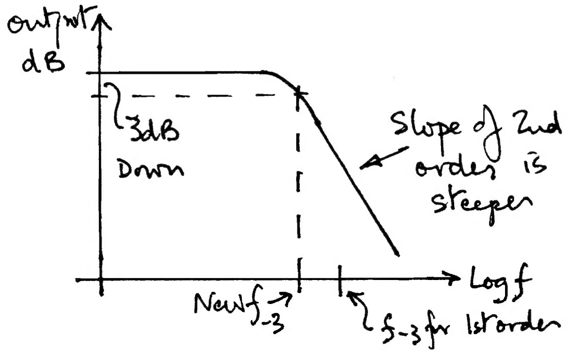
$$f = \frac{1}{2\pi RC}$$

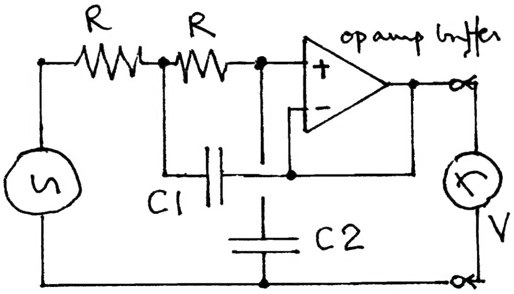
f in Hz
R in Ohms
C in Farads



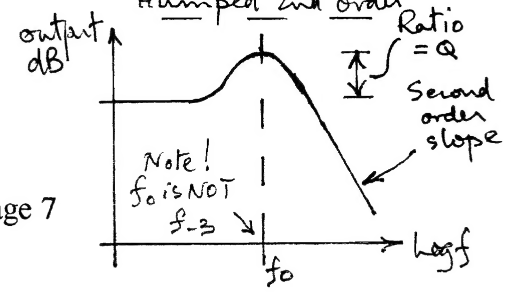
SECOND ORDER LOW PASS

If you now connect two of these CR networks in series to form a second order network as shown right, then the frequency where the response is 3 dB down is slightly lower (for the same CR product values) and the rate at which it falls off as frequency increases to 12 dB per octave or 20 dB per decade. Generally this form of second order filter is *not* often used, but an active one with some feedback mechanism is much more interesting! The third circuit shows one using an op-amp connected as a unity gain buffer. (You can use an emitter or source follower stage instead.) I have omitted the op-amp biasing for clarity. It is now possible to make the response have a peak as shown right where the Q (or sharpness) of the peak depends on the CR values. If the Q is greater than 1, there will also be some voltage gain on the peak! This is the sort of filter that is used to narrow the audio bandwidth of a DC RX to make it suitable for CW purposes. The following formulas apply:-





Humped 2nd order



$$f_o = \frac{1}{2\pi R\sqrt{C1C2}}$$

f_o in Hz
R in Ohms
C in Farads

$$Q = \sqrt{\frac{C1}{C2}}$$

C1 + C2
in same
units.

Useful stuff! Tim G3PCJ

Snippets

Phono Plugs Jim Gearey writes of the good suitability of these low cost plugs for RF purposes but warns that, because the central pin is supported by plastic, it is advisable when soldering them to have it installed in a socket to maintain the pin alignment while the plastic is soft. He sometimes also finds it necessary to file their tags to make the solder tin well.

VFO Enclosures John Teague comments that he puts his main oscillator resonator parts (L and C) in a die-cast box separate from the rest of the circuitry. This separates the heat source and improves stability. However, do give plenty of space around the coil! I think I have read that the gap between it and any metal work should be at least two coil diameters! If not, any RF currents in the box walls will alter the inductance and hence tuning. Years ago I had a chirpy transmitter, that I eventually traced to output RF currents at same frequency as the VFO getting into the walls of the VFO compartment. Tim G3PCJ

Somerset Supper

Steve Hartley, the Radcom Newcomers columnist, very kindly came along and took a very keen interest in the diner's entry tickets! For those who haven't been before, diners had to bring an item of home built gear with them as their entry ticket; these were displayed and a couple of prizes awarded. This year the standard was very high and there was a tremendous range of 'items' on display. Bob Woolridge G7LNJ was presented with the first prize – an appropriate bottle of Somerset cider brandy for his masterpiece - an oscilloscope made from a World War 2 surplus radar tube surrounded by lots of glowing valves! Although Bob was willing to demonstrate it, no suitable power source could be found for any of the signal sources also on display! Jim Gailer G3RTD earned high praise, and the runners up prize, for his surface mount DDS based signal source for 2m satellite working.

The provisional date for the 23rd QRP Convention is April 15th 2007 and I am expecting that Ben Nock of PW fame will be our

Subscriptions!

I am afraid its that time again! If you wish to continue receiving Hot Iron, let me have your cheque for £7 before Sept 1st for the next issue. I still have loads of crystals which I am unlikely to make any use of, so let me know if you would like any of the following frequencies - free apart from the packing & postage - as many as you like within reason! I will send these out (when I am here - see front page) on receipt of your sub so please add two first class stamps for the packing/postage of the crystals or increase the sub figure to £8. The following are available:-

Parallel Resonant – MHz - 5.0688, 5.6914, 5.752, 6.0177, 7.20, 9.30, 9.60, 10.2775, 10.44, 11.0258, 12.73819, 14.84830, 15.375, 16.5888, 16.623333, 17.9, 18.26, 20.105, 20.78

Series Resonant – MHz - 15.0, 18.0, 20.0, 21.0, 24.0

I have some TTL oscillators (sq wave output) £2 for P & P please - MHz 24.0, 30.0, 32.0

Send off your cheques now!

But don't forget I am out of circulation for most of July!